Biomorphic Explorers: Science Applications Overview

David Crisp, Chief Scientist, NASA New Millennium Program

With the successful Mars Pathfinder Mission, NASA has inaugurated a new era of in-situ exploration of the solar system. During the next decade, space scientists have ambitious plans to return to the surfaces of the Earth's Moon and the planet Mars, and to initiate in-situ investigations of Jupiter's moon, Europa, the Saturnian moon, Titan, as well as comets and asteroids. The overall goal of these investigations is to understand the origin and evolution of our planetary system, and the physical and chemical processes that led to the origin of life. A broad range of technologies will be needed to address these objectives. Small, highly mobile, autonomous platforms, such as biomorphic explorers, will be particularly valuable for studies of the surfaces and near-surface environments of planets, satellites, and small bodies. Such systems would augment conventional stationary landers and wheeled rovers by enhancing the spatial sampling, or by deploying sensors in places that are not accessible to these more conventional deployment systems. Large numbers small, but dexterous explorers would be of particular values for emplacing sensors for studies of spatial variations in the thermal, chemical or mechanical properties of a body. If these explorers have low enough costs and masses to be considered expendable, they could also be used to deploy instrument packages in locations that are too dangerous for conventional landers or rovers. A number of specific examples of such applications will be addressed in this talk.

Biomorphic Explorers Workshop

Science Applications Overview

David Crisp
Chief Scientist, NMP

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Objectives of this Presentation

- Provide a brief, incomplete summary of potential science applications for biomorphic explorers
- Introduce ways the the New Millennium Program might contribute to the development of these systems.
- Encourage an active dialog among scientists, technologists, and mission planners to identify additional opportunities for their use.

Science Applications

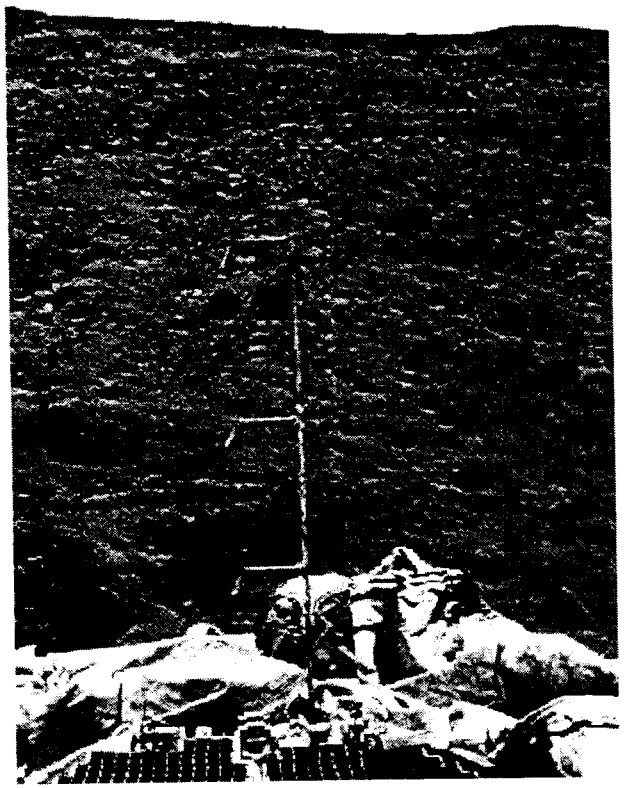
Science Applications

Biomorphic explorers could be particularly valuable for in-situ exploration of the surfaces of planets, satellites, and small bodies by

- deploying sensors and imaging systems in places that are not accessible or too dangerous for conventional landers and rovers
- enhancing the spatial sampling of biological, chemical, and thermal sensors

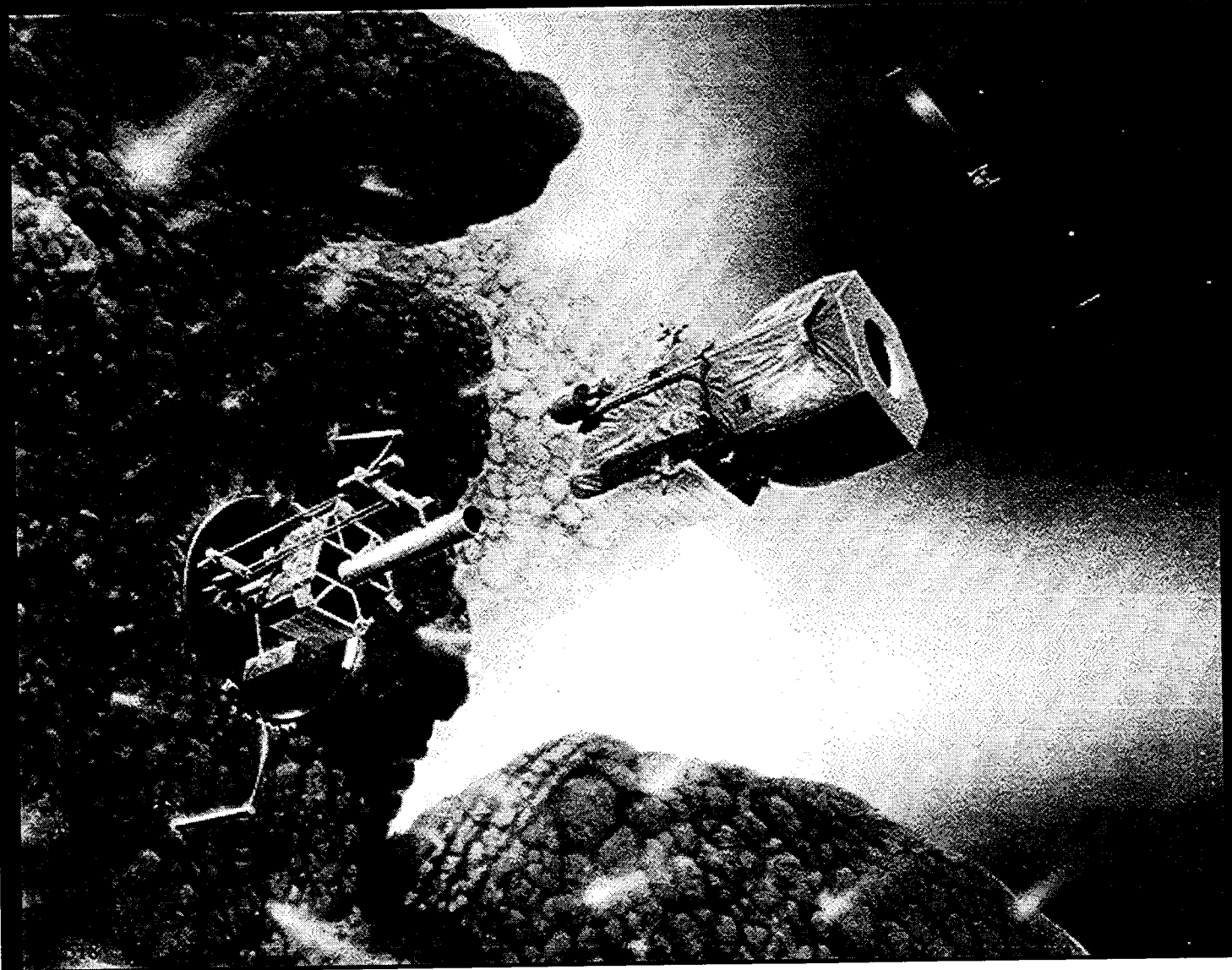
Biomorphic autonomy systems based on neural networks might also be useful for coordinating networks of small free-flying micro-spacecraft

Other Opportunities



Our Exploration of Mars has just begun

- The exploration of the Martian surface will require a broad range of technologies, including
  - Conventional landers
  - Micro-Landers
  - Mobile laboratories
  - low-cost (expendable), dexterous, biomorphic systems



NMP Objectives and Scope

New Millennium Program Objectives

Flight validating breakthrough technologies to revolutionize NASA's space and Earth science programs in the 21st Century:

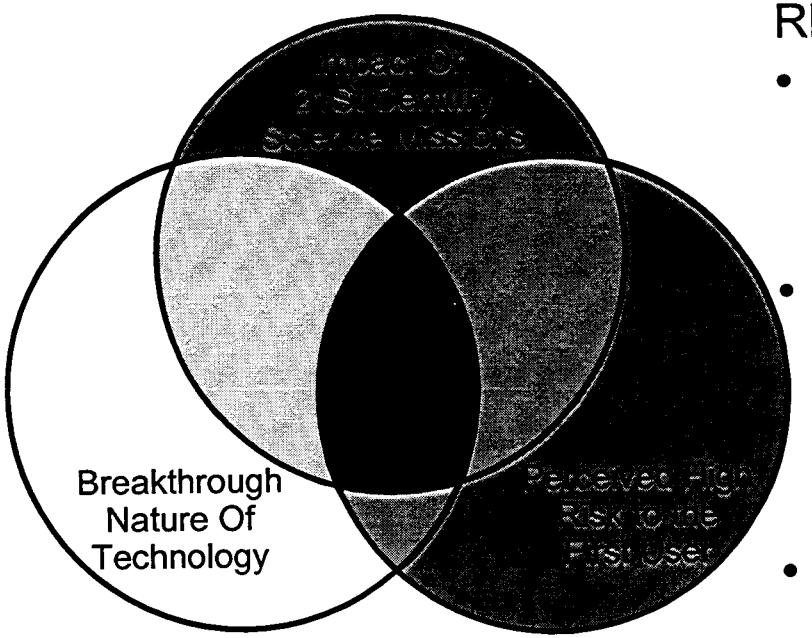
1. Enhancing spacecraft and measurement capabilities

2. Validating innovative measurement concepts

3. Reducing mission development times and life cycle costs

4. Promoting nationwide teaming and coordination of technology development efforts at NASA centers, other government agencies, industry, and academia.

New Millennium Program Objectives



PROGRAM OBJECTIVE:

- Space flight validation of breakthrough technologies for 21st Century Science missions
  - "Also designed to return high priority science data within cost and mission constraints"*

REQUIREMENTS:

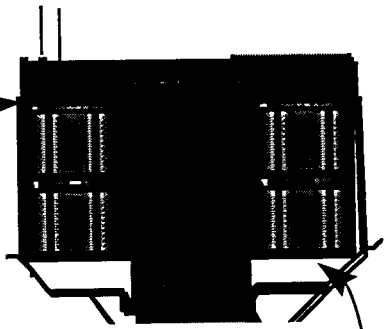
- "Impact on 21st Century Science Missions"
  - Alignment with OSS Strategic Plan and Science themes
- Breakthrough Technologies
  - Alignment with core technology programs to identify and accelerate breakthrough technologies into validation flights
- Flight Validation Needed to Mitigate Perceived High Risk to first users
  - Technologies requiring validation in space
  - Major system technology paradigm shift

* Space Science Enterprise Strategic Plan - Nov. '97

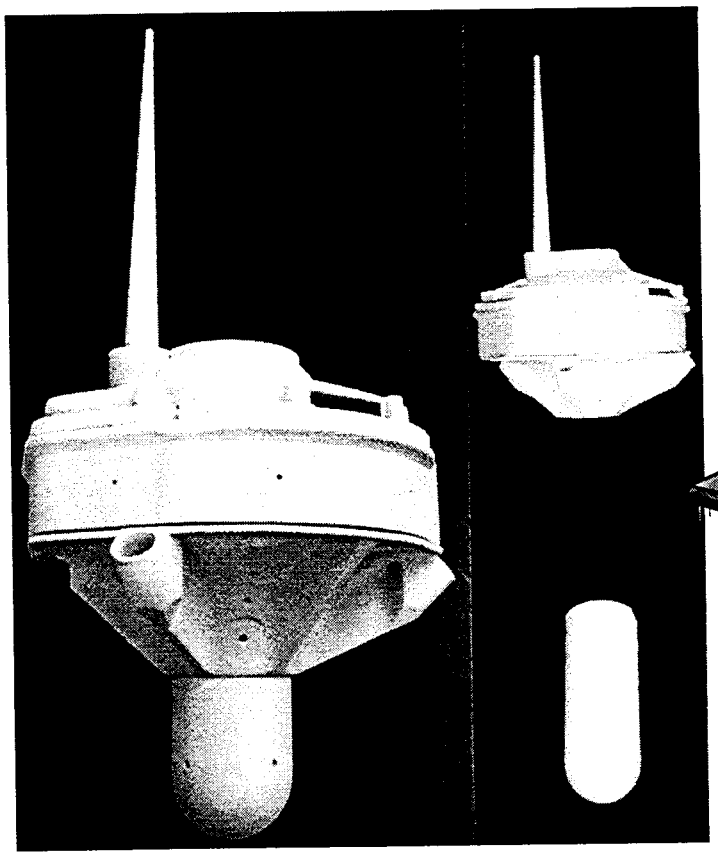
FY	98	99	00	01	02	03
DS1						
DS2						
EO1						
EO2						
DS3 target launch window						
DS4 target launch date						
Potential Small DS5 mission						
Potential EO3 / EO4						

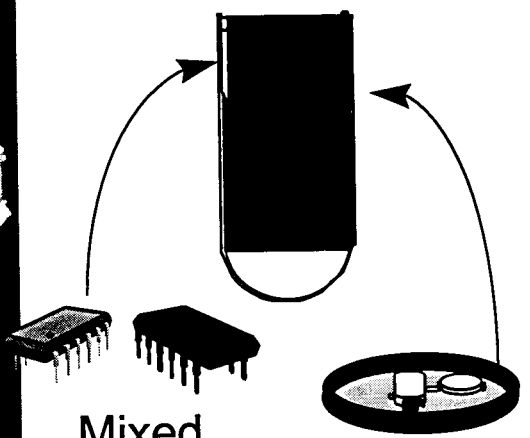
DS2
Aeroshell

Compact
Telecom



Low
Temperature
Batteries



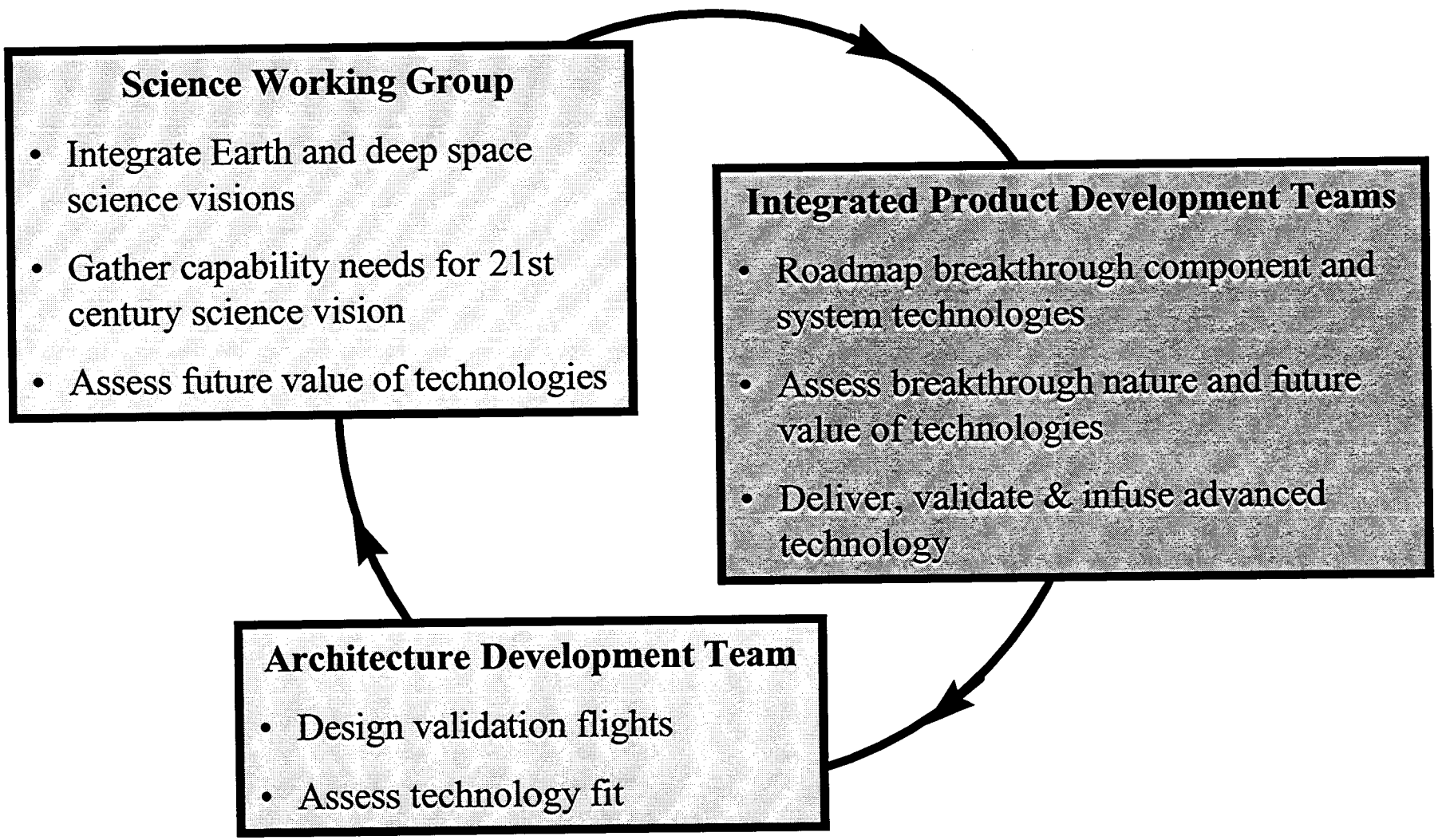


Mixed
Analog /
Digital
ASICs

Water
Detection
Instrument

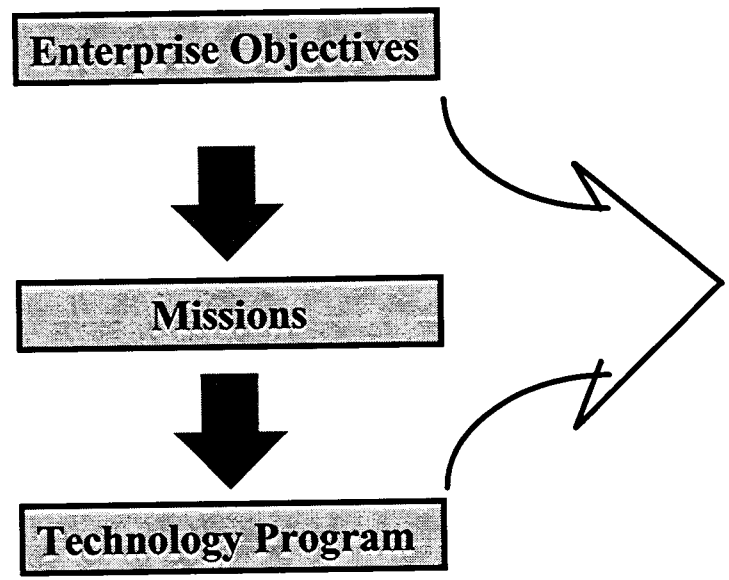
Working Together

NMP Structure



NASA TECHNOLOGY INVESTMENTS

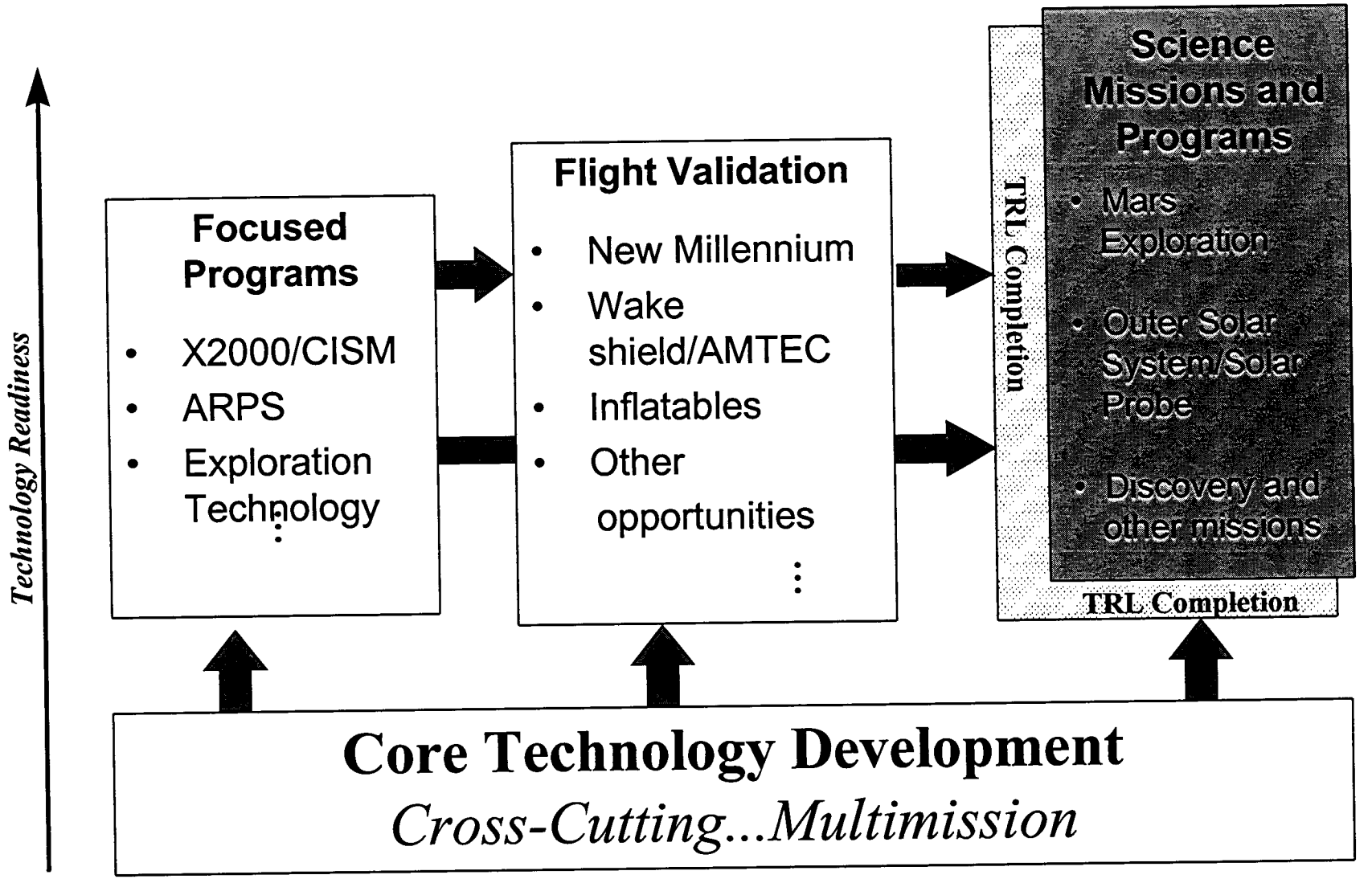
SHIFT FROM TECHNOLOGY DERIVED FROM MISSIONS TO MISSIONS ENABLED BY TECHNOLOGY



- Enterprise objectives established
- Missions sets derived from Enterprise objectives
- Technology programs derived from mission requirements

- Enterprise objectives drive technology
- Technology expands mission horizons
- Missions evolve from convergence of objectives and technology

Integrated Technology and Mission Program



NMP Technology Infusion Pre-Flight

Identify target customers, and use their input to:

- **Determine application domain and requirements**
- **Tailor technology to function within required operating envelope**
- **Identify critical flight validation issues**
- **Formulate validation plan to address critical issues**
- **Identify appropriate validation testbeds**

Issues & Barriers:

- **"Real" missions don't include "unavailable" technologies**
- **Tension between "planned" mission needs versus breakthroughs that will redefine missions**
- **Compelling benefits difficult to assess without system trade studies**

NMP Technology Infusion Flight

- Integrate technology into NMP validation flight
- Conduct flight validation
- Document results
- Assess benefits for next user

Issues & Barriers:

- NMP value is in flying technologies that
  - carry high perceived risk
  - have large flight/ground system impact
  - are not amenable to pre-flight ground validation
- Balance between demands of documentation and fast turn-around
- Benefits may not be realized in validation scenario

NMP Technology Infusion
Post-Flight

- **Disseminate validation results**
- **Clarify benefits to gain customer acceptance**
- **Provide support to mission designers**
- **Provide support to mission implementers**